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ANALYZING AND COMPARING THE DISTRICTS OF ISTANBUL USING TOPSIS

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The aim of the present study is to analyze and compare the districts of Istanbul, regarding the main aspects affecting living conditions, through TOPSIS. The problem is considered as a multi-criteria decision making problem. The criteria taken into account in this paper are population, security, education, health and environment. The problem is then solved using TOPSIS and the districts of Istanbul are compared.

Keywords: Metropolitan, Living conditions, TOPSIS, Multi-criteria Decision making.

Introduction

Istanbul, being the most populous city in Turkey, is the country's economic, cultural, and historical center. Having the population of over 14 million people with a growth rate of 3.45%, Istanbul is suffering from over-crowdedness, a typical problem of the metropolitans in the world. This results in several problems, such as; social problems like shortage of housing and increase in crime rate, environmental problems like pollution, or economic problems like unemployment.

There are not any MCDM studies to compare districts based on living conditions or happiness level. The studies are mainly conducted to choose or rank cities. In 1995, Kahn used a preference approach to rank cities based on quality of life. In 2006, Saaty gave an example in his article for choosing the best city to live in using AHP. Apart from MCDM studies, statistical analysis were made to evaluate happiness levels. In 2008, Smyth and Qian conducted a large-scale survey to analyze levels of happiness for 31 cities in China. In 2013, Shamsuddin et. al evaluated the happiness level of the streets in Kuala Lumpur.

This study aims to analyze the living conditions of Istanbul using the statistical data and compare the districts according to their key indicators. These indicators, selected among social, economic, environmental and demographic factors, are taken into account as the criteria. Alternatives are selected among the main districts of Istanbul and the comparison is made with the aid of Multi-Criteria Decision Making.

The model developed uses statistical data to calculate the effects of the criteria and the districts over each criterion. The analysis is then conducted using TOPSIS and the districts of Istanbul are sorted through their overall scores. Afterwards, a sensitivity analysis is applied to analyze system's behavior to changes.

The remainder of this paper is organized as follows. Section 2 presents Istanbul and its Districts. Section 3 introduces some definitions and formulations related to TOPSIS. In addition, the steps of the methodology are defined in the same section. Criteria and Selected Districts for Comparison are given in Section 4, along with the network. In Section 5, the application is processed and the results are analyzed. The last section summarizes the findings and makes suggestions for further research.

Istanbul and its Districts

Istanbul is the most populous city in Turkey, and the country's economic, cultural, and historical center. Founded around 660 BC as Byzantium, the city now known as Istanbul developed to become one of the most significant cities in history. For nearly 16 centuries following its reestablishment as Constantinople in 330 CE, it served as an imperial capital for the Roman, the Byzantine, and the Ottoman empires (From 330 to 1922). It was instrumental in the advancement of Christianity during Roman and Byzantine times, before the Ottomans conquered the city in 1453 and transformed it into an Islamic stronghold and the seat of the Ottoman Caliphate.

Istanbul has 39 districts; 25 of them are on the European side, 14 of them are on the Asian side. Figure 1 shows the city divided to its districts.

Figure 1. District map of Istanbul

Istanbul has a population of 14,160,467 (Turkish Statistical Institute, 2013). It is almost 3 times more populated than the second biggest city, Ankara which has a population of 5,045,083. Istanbul is the densest city with a population density of 2.725 per km^2. This is 27 times denser than Turkey's average, which actually creates a huge problem in managing (Turkish Statistical Institute, 2013).

The following figures show the situation of Istanbul from different aspects, and its comparison with the other cities of Turkey. Figure 2 shows the number of elementary school students per teacher. Istanbul does not have a significant difference than country's average, but being the most populated city, Istanbul has students more than most of the cities in Turkey.

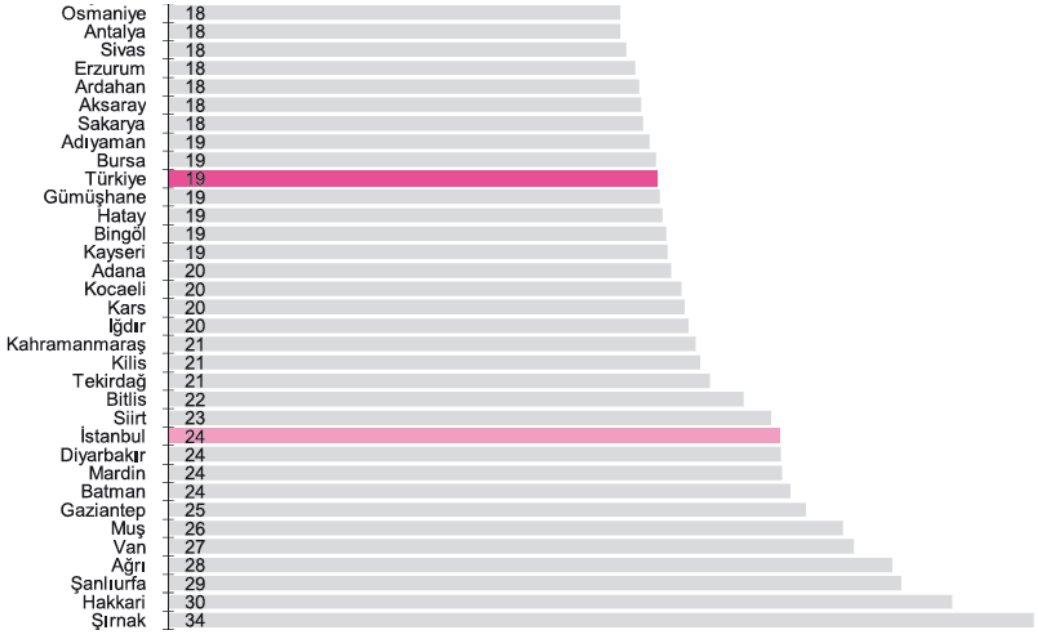

Figure 2. # of elementary school students per teacher (Turkish Statistical Institute, 2013)

In Figure 3, number of hospital beds per 100.000 people in the cities of Turkey is given. Istanbul, with 233 hospital beds per 100.000 people, is below Turkey's average. Even though the city has a lot of state and private hospitals, but it is not enough for the current population. Therefore, better management is necessary.

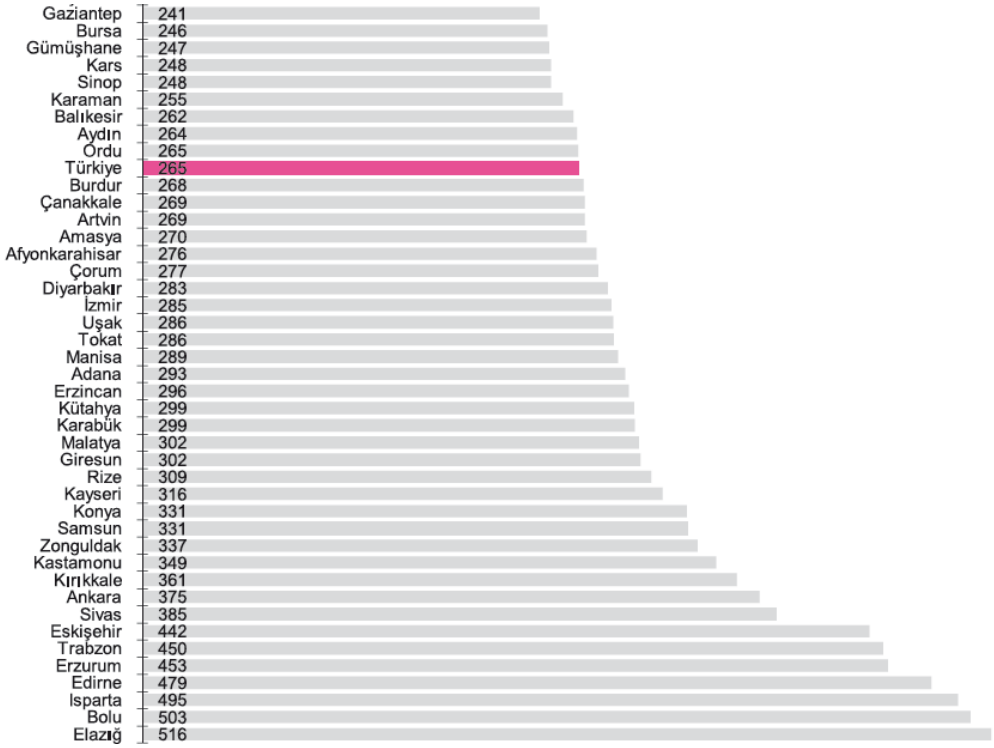

Figure 3. # of elementary hospital beds per 100.000 people (Turkish Statistical Institute, 2012)

It can be seen from Figure 4, there are 2 types of cities that are more unemployed than the average. One is the group of cities from the southeastern part, where there is the terrorism problem, and the other group is group major cities, mainly Istanbul, Izmir and Ankara. These cities have a lot of job opportunities, but overpopulation creates the unemployment problem.

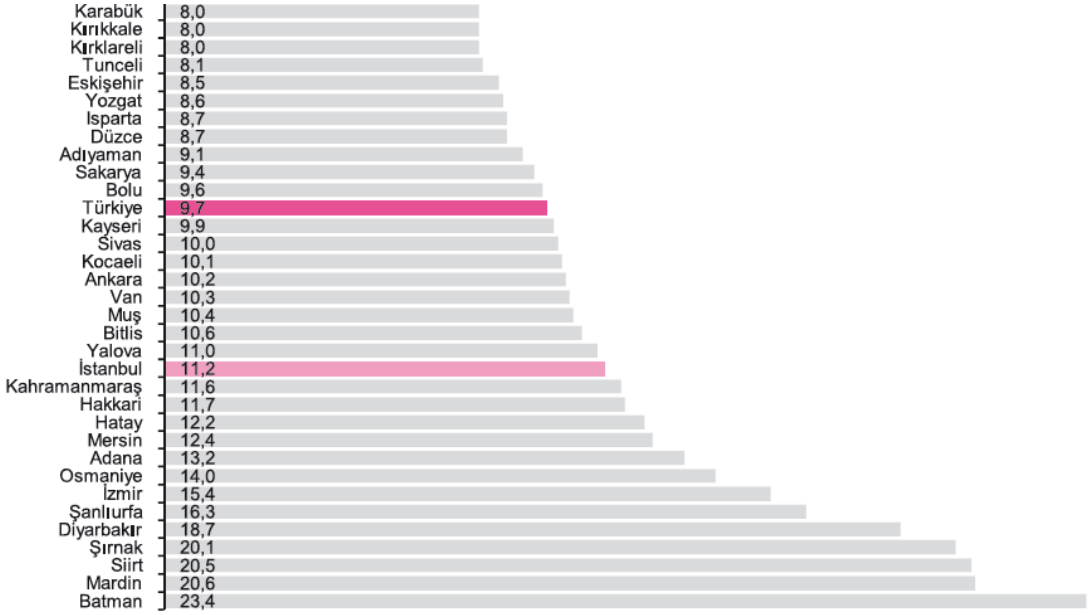

Figure 4. % of unemployment (Turkish Statistical Institute, 2013)

The happiness level of Istanbul is similar to Turkey's average (Shown in Figure 5). Being the most important and most populated city, improving Istanbul's happiness will significantly improve Turkey's happiness level. So, analyzing and understanding this city's problems is essential, and this study aims to do that in detail.

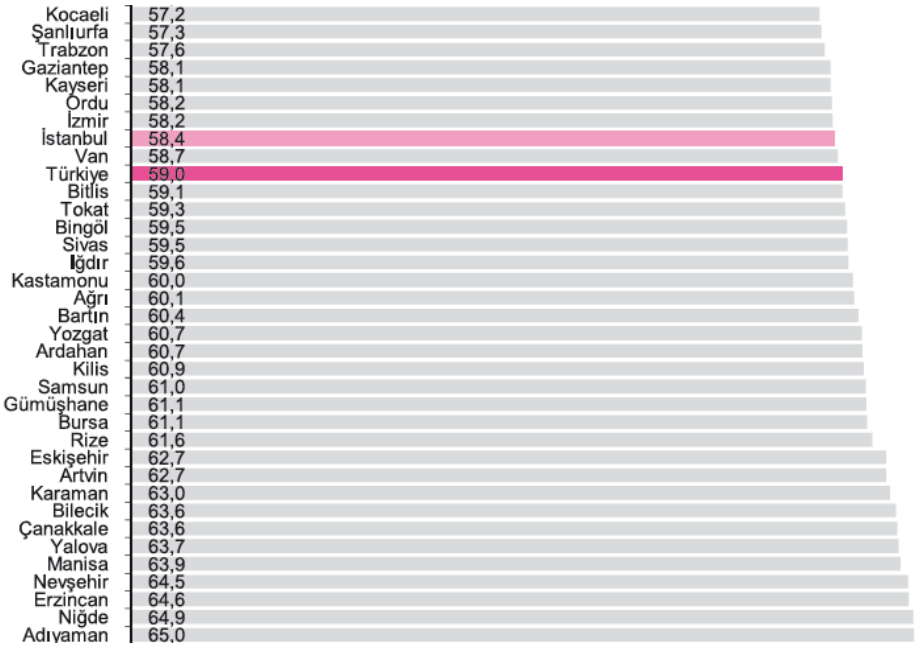

Figure 5. % of happiness level (Turkish Statistics Almanac, 2013)

TOPSIS

Selecting or prioritizing alternatives from a set of available alternatives with respect to multiple criteria is often referred to as Multi-Criteria Decision Making. Academics have developed and used various MCDM methods to solve different problems (Chang 1996; Cheng et al. 1999; Dağdeviren et al. 2007; Demirel et al. 2009; Gu and Zhu 2006; Kahraman et al. 2004; Mikhailov 2002).

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a multi-criteria decision analysis method, which was originally developed by Hwang and Yoon in 1981. TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. TOPSIS is being used in different areas recently; such as to support decision of waste management (Cheng et. al, 2002), to compare financial ratios (Deng et. al, 2000) and in process selection (Parkan and Wu, 1998).

The methodology is composed of six steps:

Step 1. Create an evaluation matrix consisting of m alternatives and n criteria, with the intersection of each alternative and criteria given as x_{ij}, we therefore have a matrix $(x_{ij})_{mxn}$.

Step 2. The matrix $(x_{ij})_{mxn}$ is then normalized using the normalization method

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x^2_{ij}}}$$

Step 3. Construct the weighted normalized decision matrix. Assume we have a set of weights for each criteria w_j for j = 1,…n. Multiply each column of the normalized decision matrix by its associated weight. An element of the new matrix is:

$$v_{ij} = w_j \, x \, r_{ij}$$

Step 4. Determine the ideal and negative ideal solutions.

- Ideal solution.

$$A^* = \{v_1^*, \ldots, v_n^*\}, \text{ where } v_j^* = \{\max(v_{ij}) \text{ if } j \in J ; \ \min(v_{ij}) \text{ if } j \in J'\}$$

- Negative ideal solution.

$$A' = \{v_1', \ldots, v_n'\}, \text{ where } v' = \{\min(v_{ij}) \text{ if } j \in J ; \ \max(v_{ij}) \text{ if } j \in J'\}$$

Step 5. Calculate the separation measures for each alternative.

- The separation from the ideal alternative is:

$$S_i^* = \left[\sum_j (v_j^* - v_{ij})^2 \right]^{1/2}, \qquad i = 1, \ldots, m$$

- Similarly, the separation from the negative ideal alternative is:

$$S_i' = \left[\sum_j (v_j' - v_{ij})^2 \right]^{1/2}, \quad i = 1, \ldots, m$$

Step 6. Calculate the relative closeness to the ideal solution C_i^* and Select the Alternative with C_i^* closest to 1.

$$C_i^* = S'_i / (S_i^* + S'_i), \qquad 0 < Ci^* < 1$$

Criteria and Selected Districts for Comparison

Experts' views and the studies on this matter were analyzed in determining criteria in comparing the districts of Istanbul. The definitions of the criteria are summarized as follows:

- **Demography:** The analysis of population for the district. It is determined by population density.
- **Security:** The safety level of the district. It is determined by crime rate.
- **Education:** The accessibility to education in the district. It is determined by the # of students per teacher.
- **Health:** The accessibility to healthcare in the district. It is determined by the # of patients per doctor.
- **Environment:** Analysis of environmental issues and availability of green space in the district. It is determined by the municipal spending for environment per citizen.

The districts compared are selected among their location and importance to the city:

- **Bakırköy:** One of the biggest and most centric district of Istanbul, which connects the old and new part of the city
- **Beşiktaş:** Can be seen as the unofficial center of Istanbul, and probably the most wealthy district by having important business centers and skyscrapers
- **Fatih:** Main district of Istanbul where the city municipilaty is located
- **Kadıköy:** Main district of the Asian side

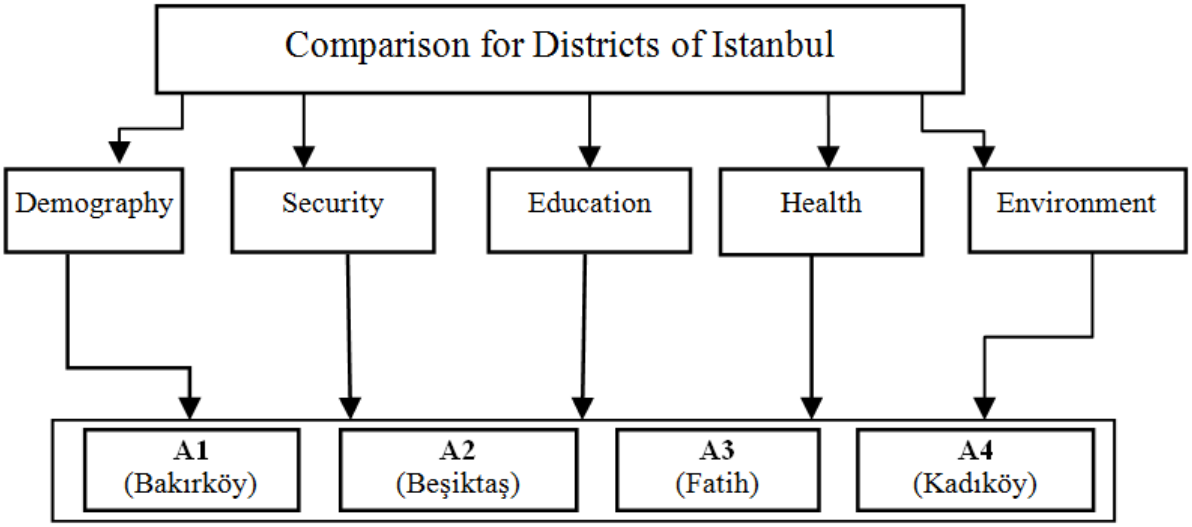

Figure 6. The Hierarchical Network of the Proposed Model

Application

The aim of this study is to analyze and compare the selected districts of Istanbul with respect to the determined criteria. The data are obtained from statistical analyses and using the constructed model in the previous section, the districts are then compared through TOPSIS.

The data for each criterion are collected from state agencies and Turkish Statistical Institute and given in the following tables.

Table 1. Demography (Cost Attribute)

District	Population	Area (m^2)	Density (per 1000 m^2)
Bakırköy	220.974	29.640.000	7,46
Beşiktaş	186.570	18.010.000	10,36
Fatih	425.875	15.590.000	27,32
Kadıköy	506.293	25.090.000	20,18

Table 2. Security (Cost Attribute)

District	Population	# of Crimes	Crime Rate (%)
Bakırköy	220.974	16.448	7,44
Beşiktaş	186.570	11.462	6,14
Fatih	425.875	17.948	4,21
Kadıköy	506.293	21.053	4,16

Table 3. Education (Cost Attribute)

District	# of Students	# of Teachers	Rate
Bakırköy	44.861	3.134	14,31
Beşiktaş	36.804	2.882	12,77
Fatih	79.028	3.982	19,85
Kadıköy	64.010	4.844	13,21

Table 4. Health (Cost Attribute)

District	Population	# of Doctors	Rate
Bakırköy	220.974	1.079	204,80
Beşiktaş	186.570	723	258,05
Fatih	425.875	1.231	345,96
Kadıköy	506.293	1.584	319,63

Table 5. Environment (Benefit Attribute)

District	Population	Municipal Spending (TL)	Rate
Bakırköy	220.974	32.870.724	148,75
Beşiktaş	186.570	37.394.150	200,43
Fatih	425.875	52.598.901	123,51
Kadıköy	506.293	45.674.213	90,21

Using the calculated rates for each criterion, the comparison matrix is formed. The values are then normalized and multiplied with criteria weights to obtain the weighted normalized matrix. The weights of the criteria are taken as equal (0.20 for each criterion).

Table 6. Weighted normalized matrix

District	Demography	Security	Education	Health	Environment
Bakırköy	**0,0411**	0,1315	0,0935	**0,0713**	0,1016
Beşiktaş	0,0571	0,1085	**0,0835**	0,0898	**0,1369**
Fatih	0,1506	0,0744	0,1297	0,1204	0,0844
Kadıköy	0,1112	**0,0735**	0,0863	0,1112	0,0616

Using the values from Table 6, ideal and negative ideal solutions are calculated. In ideal solution, lowest values are used for the first four criteria and the highest value for environment; vice versa in negative ideal solution.

- Ideal Solution

$$A^* = \{0{,}0411;\ 0{,}0735;\ 0{,}0835;\ 0{,}0713;\ 0{,}1369\}$$

- Negative Ideal Solution

$$A' = \{0{,}1506;\ 0{,}1335;\ 0{,}1297;\ 0{,}1204;\ 0{,}0616\}$$

Then, separation measures for each alternative are calculated:

- The separation from the ideal alternative

$$S_1^* = 0{,}0687 \qquad S_2^* = 0{,}0428$$
$$S_3^* = 0{,}1389 \qquad S_4^* = 0{,}1104$$

- The separation from the negative ideal alternative

$$S_1' = 0{,}1316 \qquad S_2' = 0{,}1342$$
$$S_3' = 0{,}0614 \qquad S_4' = 0{,}0830$$

From the separation measures, relative closeness to the ideal solution for each criterion is obtained. The findings are then presented and interpreted:

$$C_1^* = 0{,}6570 \qquad C_2^* = 0{,}7584$$
$$C_3^* = 0{,}3065 \qquad C_4^* = 0{,}4290$$

The findings show us that Beşiktaş is the best district among the selected ones. Fatih and Kadıköy are distinctly worse than the other districts, mainly due to their crowded population.

Conclusion

The aim of this study was to compare districts of Istanbul regarding the main aspects affecting living conditions, through TOPSIS. The findings show us that TOPSIS, with its simplistic structure, is suitable to conduct this kind of study.

TOPSIS is able to take into account the interaction between criteria and alternatives. The evaluation criteria have different measurement units. So TOPSIS, with its adaptable and easy-to-use structure is suitable for comparing districts.

For further research, a comprehensive study can be made to analyze all districts of Istanbul. This is a necessity since Istanbul, with its population and structure, is similar to a small country more than a city.

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